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LIMITATIONS ON CANADA GOOSE PRODUCTION AT FISH SPRINGS NATIONAL WILDLIFE REFUGE, UTAH

by

DORIE S. STOLLEY
JOHN A. BISSONETTE
JOHN A. KADLEC

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EXECUTIVE SUMMARY

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LIMITATIONS ON CANADA GOOSE PRODUCTION

AT

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DORIE S. STOLLEY[1,2]
JOHN A. BISSONETTE[1,2]
JOHN A. KADLEC[2]

UTAH COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT[1,2]
(U.S. Geological Survey-Biological Resources Division)
DEPARTMENT OF FISHERIES AND WILDLIFE[2]
COLLEGE OF NATURAL RESOURCES
UTAH STATE UNIVERSITY
LOGAN, UTAH
Voice (435) 797-2558, Fax 435-797-4025, E-mail fajohn@cc.usu.edu

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PREFACE

This is the final report[1] for a project funded by the Contaminants Program of the U.S. Fish and Wildlife Service (Salt Lake City) and by the Utah Division of Wildlife Resources. It is a summary of findings especially important for the USFWS, particularly Fish Springs NWR. Additional information may be found in the thesis[2] from which this summary was abstracted. The thesis is located at the Quinney Library at Utah State University and at Fish Springs NWR. It may also be obtained through Interlibrary Loan Services at any major library, or from the Cooperative Fish and Wildlife Research Unit. This project was coordinated and administered by the Utah Cooperative Fish and Wildlife Research Unit. The Unit is a federal installation based at Utah State University whose activities are overseen by its coordinating committee, comprized of representatives from Utah State University, the Utah Division of Wildlife Resources, the Wildlife Management Institute and the U.S. Geological Survey-Biological Resources Division.

ABSTRACT

We studied the western Canada goose (*B. c. moffitti*) population at Fish Springs National Wildlife Refuge in western Utah from March to July in 1996 and 1997 to determine the causes of low gosling production. Our initial interest was in whether water salinity was involved. We researched the effects of saline drinking water by conducting an experiment on *captive* wild-strain goslings that were collected as eggs from Cutler marsh in Cache County, Utah and by observing *free-ranging* broods in the brood-rearing impoundments. Mortality occurred in captive goslings at 18 µS/cm; effects on growth were evident at 12 µS/cm. We identified 11 hydrologically distinct areas within the 9 impoundments at the refuge. From 15 April

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[1] This report may be cited as: Stolley, D. S., J. A. Bissonette, and J. A. Kadlec. 1998. Executive Summary: Limitations on Canada goose production at Fish Springs National Wildlife Refuge, Utah. UTCFWRU 98(1):1-20.

[2] Stolley. D. S. 1998. Limitations on Canada goose production at Fish Springs National Wildlife Refuge, Utah. M.S. Thesis, Utah State University, Logan. 105 pp.

to 15 July, conductivity measurements ranged from 3.1 to 25.4 µS/cm within these areas. Our results suggest that at the levels that goslings experienced during the critical hatchling period during 1996 & 1997, salinity was not a serious problem. During exceptionally dry years, if salinity levels rise during early spring, then its effects might be more directly related to gosling mortality. At the levels we measured during this study, mortality in free-ranging goslings was independent of specific conductivity. Rather, annual goose production appeared to be limited by predation and human disturbance. This conclusion is supported by 2 lines of evidence: a) low ground-nest success, and b) low gosling survival. Ground nests had lower nest success (56%-9 of 16 nests) in both years than artificial nesting platforms (90%-9 of 10 nests). Gosling survival to fledging was 25% and 52% in 1996 and 1997, respectively, well below survivorships levels reported in the literature. Our observations suggest that coyotes are abundant on the refuge and we observed them hunting for geese. Human disturbance appears to predispose goslings to mortality because goslings often became separated from their parents after disturbance. Low productivity also is related to the low number of breeding pairs on the refuge. During the summers 1996 and 1997, number of nesting pairs of geese averaged 26 and 39, respectively.

INTRODUCTION

Although goose populations are thriving elsewhere in North America, the western Canada goose (*Branta canadensis moffitti*) has experienced low production of goslings at Fish Springs National Wildlife Refuge (FSNWR) since at least 1987. The number of goslings surviving to fledging age (approximately 70 days) ranged from 17 to 34 per year from 1989 to 1995 (no data for 1994). FSNWR is located in the west desert of Utah in part of the former Lake Bonneville lake basin, and is characterized by high salinity in both the soils and water. Refuge personnel and others have expressed concern that the high salinity of the brooding impoundments may be causing low gosling survival.

GOALS AND OBJECTIVES

The goal of this study was to determine if there are limitations on gosling production at Fish Springs NWR, and, if so, to examine the causes. To do this, we addressed 3 major objectives. We wanted to:

1. examine the effects of saline drinking water on gosling survival and growth,
2. determine if, and at what stage in the reproductive cycle, production is being limited, and
3. suggest options for goose and gosling management.

STUDY AREA

Fish Springs NWR is located at the southwest edge of the Great Salt Lake Desert in Juab County, Utah (Fig. 1). The refuge is at an elevation of 1,311 m (4,300 ft), and receives an average of 20 cm (≈ 8 in) of rain annually. Temperatures range from -26.1 to 42.7 C (≈ -15 to 108 F) . The refuge is 7,282 ha (17,992 ac) in size and contains approximately 3,604 ha (8,905 ac) of saline marsh, 2,867 ha (7,084 ac) of mud and alkali flats, and 811 ha (2,003 ac) of semi-desert uplands. At optimum water levels there are about 1,416 (3,500) surface hectares of water in a complex of pools, sloughs, and springs. As ancient Lake Bonneville lake bottom, the refuge is flat, and the soil is saline and alkaline.

Five major, and several minor thermal springs arise from a fault line running parallel to the east side of the Fish Springs mountain range (Fig. 1) and feed the refuge's marsh. The springs are moderately brackish with specific conductivity measurements ranging from 2.9 to 3.4 μS/cm, except for North Spring which measures 5.1 μS/cm. For comparison, fresh water measures about 0.3 μS/cm.

An aerial photograph taken before modification of the wetlands began (*circa* 1960) shows an area of sloughs and narrow waterways lined with emergent marsh vegetation (Fig. 2). After the refuge was established in 1959, 9 large, shallow pools, impounded by dikes and fed from the springs through canals, were created, enlarging and modifying the natural marsh. Much of the area covered by the more southern impoundments, *viz*., Avocet, Mallard, Curlew, Egret, and Shoveler, was part of the original slough; thus, there are numerous islands and peninsulas. The southernmost impoundments also are closer to the springs that provide their water. Because of this, and because the soil underlying these impoundments is flushed continually with water of relatively low salinity, most of the year the water in these pools is only slightly to moderately more saline than the springs. The impoundments contain typical emergent marsh vegetation, e.g., Olney's three-square bulrush (*Scirpus americanus*), cattail (*Typha domingensis*), hardstem bulrush (*S. acutus*), alkali bulrush (*S. maritimus*), wirerush (*Juncus arcticus*), and saltgrass (*Distichlis spicata*). Abundant mats of submergent vegetation, primarily wigeongrass (*Ruppia maritima*) and muskgrass (*Chara* spp.), and spiny, or pond naiad (*Najas marina*), and coontail (*Ceratophyllum demersum*) grow in the springs, canals, and pools. Additionally, the native *Phragmites australis* has expanded into much of the marsh.

The northern impoundments, *viz*., Ibis, Pintail, Harrison, and Gadwall, were constructed on the northern edge of the original wetlands, and contain little of the original marsh structure. Most of the water feeding these pools comes from the southern pools that are more saline than the springs that supply them. As a result of the evaporation and leaching of salts from the original playa, the water in the northernmost impoundments is more saline than in the southern impoundments. The water in these impoundments is reduced, often severely, during the summer because the volume of spring input does not match evaporation rates. The bordering vegetation is characterized by saltgrass (*Distichlis spicata*), pickleweed (*Allenrolfea occidentalis*) and annual samphire (*Salicornia europaea*). The ponds contain little emergent or submergent vegetation. However, sloughs in these impoundments are fed from the less saline main canal, or from North Spring, and specific conductivities range from 4.7 to 7.5 µS/cm during the breeding season. They contain vegetation similar to the southern sloughs.

METHODS

We conducted an experiment on captive wild-strain goslings that were collected as eggs from Cutler marsh in Cache County, Utah. Immediately after hatching each gosling was randomly assigned to one of three treatments; tap water at about 0.3 µS/cm , and more saline water collected from the impoundments and adjusted to 12 µS/cm and 18 µS/cm. The goslings were given commercial chick food and water *ad libitum*. We measured body mass, wing length and culmen length of the goslings daily from day 1 to 28 following hatching.

We measured specific conductivity on a weekly basis at 17 water control structures along canals and at the edges of impoundments in order to identify if hydrologically distinct locations within the marsh existed, and if so, to quantify the salinity levels at each location over the course of the breeding season.

To determine the location and number of goslings in every brood daily from hatching through day fifteen, we marked adults and found and monitored nests. We trapped molting, breeding adults in 1996, and placed individually marked plastic neck collars on them. In 1997, we trapped and put radio-collars on nesting females when their eggs were pipping. We used telemetry and observations to locate broods. We conducted all observations and radio tracking from the dikes surrounding each impoundment.

To test the relationship between salinity of drinking water available to goslings and mortality using a chi square analysis, we first calculated daily estimates of specific conductivity. Next, we classified brood locations during day 1 through day 15 following hatching as either low (<8.2 µS/cm) or high (≥8.2 µS/cm) conductivity. These levels were determined arbitrarily. We tabulated the day of mortality for all deaths until day 15. For this analysis, we did not use broods that were in an unknown location for more than 2 days. Likewise, if a brood found mostly in high conductivity locations was found in a low conductivity location for more than 2 days, or *vice versa*, we did not use it in the analysis.

To quantify number of territorial pairs and breeding pairs, we conducted daily and weekly pair counts, and daily and twice-weekly observations of territorial and nesting behavior from 22 March to 5 May in 1996, and 21 March to 11 May in 1997. We drove slowly along the dikes that surrounded every impoundment and made observations from our vehicles using spotting scopes. Pairs, and "singles" (assumed to be lone males with a mate on a nest), aggressive behavior, and nesting behavior were recorded and location of geese marked on a map.

To determine the number of breeding pairs, we located nests. We observed artificial nesting platforms for signs of use, and checked them several times over the season. We located ground nests with a variety of techniques. The vast majority of ground nests were found searching from an airboat. Every impoundment was completely traversed by airboat at least once, and many twice during the early part of nesting seasons. Also, during our daily observations, we scanned for signs of incubating females, and small pieces of down in the vegetation indicating a possible nest. We also looked for single ganders that might be guarding an incubating female, particularly in areas that previously had a pair evident. We found several nests and general nesting areas this way. We also traversed areas of the marsh by foot and kayak.

To examine historical data on number of pairs, we searched the file archives at Fish Springs NWR headquarters for relevant information. We read Canada goose study reports for 1983 and 1989-1994 and excerpts from all annual reports. We also examined archived pair count data. Unless noted otherwise. annual and goose study reports cited in the text are from Fish Springs NWR.

To quantify clutch size, nest success, and egg success, we observed nests from a distance, checking them by foot when it was suspected that either incubation was at least a few days underway, or the nest had been abandoned. In 1996, we avoided checking either platforms or ground nests if we suspected the female was still laying. In 1997, we did not check ground nests when the female was laying. All eggs were counted, numbered, and candled to ascertain viability and approximate stage of development. We monitored status (i.e., incubating, pipping, abandoned, depredated) of all nests, either by distant observation, or by visitation. After broods had hatched and left the nest, we returned to the nest to count and collect unhatched eggs for analysis. We opened unhatched eggs to determine if they were infertile or aborted.

To quantify fledging success, and determine if mortality was related to location, we monitored gosling numbers and location by observations of collared, radio collared, and unmarked adults. Many biologists use survival to a certain age (i.e., 4-6 weeks, 8 weeks, banding) as a surrogate for survival to fledging. In this study, we used survival to banding (5.5 to 10.5 weeks after hatching) to estimate fledging success.

When we began work in 1996, there was only one collared Canada goose on the refuge. During the breeding season in 1996 we trapped 5 nesting females and collared them with yellow plastic collars inscribed with unique alpha-numeric codes. We collared additional adults and goslings during the annual roundup. Thus, by 1997, many of the nesting geese had already been collared. We concentrated our trapping activities on nests where neither parent was collared, although we attempted trapping on other nests as well. We attempted trapping when the eggs were pipping, since females are less likely to abandon their nests at this time. We approached the nest, flushed the female, and set up a bownet trap operated by remote control. We chose this design because of its low profile. We also painted it a straw color to blend in with the straw bales on the artificial nesting platforms and the dead saltgrass surrounding most of the ground nests. We then left the vicinity to allow the female to return. We returned after 2 to 4 hours to spring the trap from a distance of 50-150 m. We first tried trapping during the daytime, but many geese would not return to the nest until we removed the trap. We then began setting the trap after dark, and had more geese return to their nests.

In 1996, trapped birds were banded and collared. In 1997, the collars were equipped with radio transmitters, and were color-coded (along with the inscribed alpha-numeric code,) so we could identify them at a distance if the transmitter failed. In 1996, 3 of the 5 trapped females abandoned their nests, so in 1997, we utilized an injectable anesthesia, Propofol (Rapinovet, Mallinckrodt Veterinary, Inc.), to help prevent nest abandonment.

After broods left the nest, we returned to ascertain the number of eggs hatched. Unhatched eggs were collected and examined. We attempted to locate all broods every day for the first fifteen days following hatching, and then every other day. We located broods by telemetry or observation, and noted location and number of goslings.

RESULTS

Salinity Experiment

Mortality only occurred at the 18 μS/cm level (33%, n=9). The tap water goslings were the largest in terms of body mass, wing length, and culmen length, followed in size by the 12 μS/cm goslings. The 18 μS/cm goslings were the smallest.

Observational Study

Specific conductivity of brooding impoundments....We identified 11 hydrologically distinct areas within the 9 impoundments; from 15 April to 15 July, conductivity measurements ranged from 3.1 to 25.4 μS/cm within these areas (Stolley 1998). The general trend for all but 3 locations (Avocet, Mallard, and S. Curlew) was an increase in salinity as the season progressed. The 3 southern-most locations that received water more directly from the springs stayed within ±0.4 μS/cm of their first measurements.

Gosling location and mortality....There were 20 broods at Fish Springs NWR in 1997. We monitored 19 of these from day 1 to day 15 after hatching. We followed 7 broods with collared-marked and radio-marked females, and 5 broods without radio-marked females, but with one or more collar-marked parents. Seven broods had parents with neither radio-marks nor collar-marks; we identified these broods by age of goslings and location. The first brood hatched on 25 April, the latest on 25 May. From day 1 to day 15 after hatch, the broods used locations with specific conductivities ranging from 4.2 to 11.9 μS/cm.

Only 2 broods utilized the 3 least saline locations, and only for a few days. The second most saline impoundment, N. Gadwall, was used for a total of only 3 days. On these days its specific conductivity ranged from 9.5 to 9.6 μS/cm.

The 19 broods contained 77 goslings on hatch day. Eleven mortalities occurred between hatch day and day 1. Twenty-four more deaths occurred from day 1 through day 15. These 35 deaths accounted for 87.5% of all prefledged gosling mortalities at Fish Springs NWR in 1997.

We did a chi-squared analysis to compare gosling mortality to specific conductivity of location. We used data from 15 broods. Two broods of one gosling each were not used because the goslings either died or disappeared on day 1. A third brood was not used because we never saw it until the goslings were approximately 41 days old. Two other broods were not used because they were in unknown locations for more than 2 days each.

We placed broods into one of 2 conductivity classes based on the specific conductivity of their location during the first 15 days following hatching. Some broods moved from pool to pool, yet remained in the same conductivity class. The classes were: high salinity (≥8.2 μS/cm), and low salinity (< 8.2 μS/cm). The 15 broods we analyzed yielded a total of 63 hatched goslings. We ran a chi-squared analysis. using mortalities from hatching to day 15 (Table 1). This included information on 27 mortalities, which was 68% of the total number of mortalities (n = 40); 77% of all mortalities occurred before day 16 (n = 35). If salinity caused these mortalities. we expected a significant positive relationship between the 2 factors. We rejected the null hypothesis of independence ($\chi^2 = 9.35$, $P = 0.0093$).

Numbers of Pairs....Prior to 1978, no pair counts were made at the refuge. From 1978 to 1987. counts during the breeding season ranged from 58 to 77 pairs. No distinction between total pairs, and territorial or nesting pairs, was made. In 1988, 25 to 40 pairs were present during the breeding season. From 1989 to 1993, number of nesting pairs ranged from 18 to 22. No pairs counts were done in 1994 or 1995. In 1996, we made 24 refuge-wide goose pair counts between 22 March and 5 May. Approximately 35 pairs became territorial; 26 pairs (74%) nested.

In 1997, we made 19 counts of *indicated* pairs (i.e., pairs, plus pairs indicated by lone gander) from 21 March to 11 May. The total number of pairs ranged from 31 to 52. and averaged 41. Observations and territory mapping yielded about 43 territorial pairs. Of these, approximately 34 (79%) nested, producing 39 known nests. Thus. 5 of 34 pairs (15%) were responsible for 2 nests apiece. Our observations suggested that all renests were the result of continued laying. No first or second nests of the same pair contained more than 3 eggs or the eggshell fragments of more than 3 eggs.

Clutch Size....We calculated clutch size for all complete nests after full incubation had started. In 1996, average clutch size for artificial nesting platforms was 5.33 ± 0.71. Average clutch size for ground nests was 4.42 ± 1.51. When suspected renests were combined with their associated first nest to make one total clutch, the average clutch size for ground nests was 5.30 ± 0.82. Clutch size ranged from 2 to 6.

In 1997, average clutch size for artificial nesting platforms (n=10) was 5.70 ± 1.64. One nest contained 10 eggs, 5 of which were infertile. If the 5 infertile eggs are disregarded, average clutch size was 5.20 ± 0.63. Average clutch size for ground nests (n=19) was 4.68 ± 1.42. When suspected renests were combined with their associated first nest, the average clutch size for ground nests (n=17) was 5.29 ± 0.77. Clutch size ranged from 1 to 10.

We also calculated average clutch size for those nests that were successful (i.e., one or more eggs hatched). For this calculation, we considered nests that were abandoned when eggs were pipping due to our trapping efforts as "successful." In 1996 and 1997, average clutch size for successful nests was 5.3 ± and 5.3 ± , respectively

Nest Success....In 1996, we located 28 nests. Geese nested on 10 (58%) of 17 available artificial nesting platforms. We found 18 ground nests; 2 were abandoned due to human disturbance at the nest during laying, and the pairs renested. These 2 nests were not used in calculating nest success. We considered nests that contained pipping eggs that were subsequently abandoned due to our trapping efforts as successful nests for this calculation. Overall nest success (i.e., one or more eggs hatched) was 69%; i.e., 18 of 26 nests were successful. Nine (90%) of 10 platform nests were successful. Nine (56%) of 16 ground nests were successful.

In 1997, we located 36 nests. Twelve (70.5%) of 17 artificial platforms were utilized, 10 (83.3%) of which were successful. Ten (41.6%) of 24 ground nests were successful. Three ground nests were assumed to exist due to the appearance of broods otherwise unaccounted for, although they were not located. Thus, ground nest success may have been as high as 48.1% (13 of 27 successful). Overall nest success was 59.0% (23 of 39 successful). Since we did not find some successful nests, we probably did not find some unsuccessful nests as well. If these unsuccessful nests were present in the same ratio to successful nests as the ones we found or were indicated by brood presence, there may have been 4 more nests at Fish Springs NWR. If included in our calculations, ground nest success was 41.9% (13 of 31 successful), and overall nest success was 54.5% (23 of 43 successful).

Fate of Unsuccessful Nests....Of the 28 nests found in 1996, 7 were depredated. Five were depredated early and 2 were in advanced stages of incubation. Our nest visits may have caused abandonment in these 2 cases. Two other nests were abandoned after we visited during the laying period and while the female was on the nest.

In 1997, 13 nests were depredated, 8 by an avian predator, probably ravens. At 2 of these, we also discovered owl pellets. Three nests were depredated by coyotes (*Canis latrans*) and three by an unknown predator. Of 13 depredated nests, we do not know if abandonment came before or after the depredation. However, one may have been abandoned due to harassment at the nest, first by a golden eagle (*Aquila chrysaetos*) and then by us when we checked the nest. Another nest may have been abandoned due to harassment by conspecifics; we observed aggressive interactions between geese in the nest vicinity both before and after the depredation.

In 1997, 2 nests were abandoned. One was abandoned after we visitated during the laying period and while the female was on the nest; the female renested within 25 m. The other was abandoned after we visited the nest, however the eggs contained normal embryos already dead, and were approximately 9 days from hatching.

Egg Success....In 1996, 18 nests were successful. We computed egg success using the 14 nests that had complete histories (Table 2). Seventy-five eggs were used in the calculations. Two (2.7%) were infertile, one (1.3%) was decomposed, and 2 (2.7%) contained normal embryos that had not hatched. Overall, 5 (6.7%) eggs did not hatch, giving a success rate of 93.3%. We examined all of the eggs that did not hatch and found no evidence of physical deformities.

We calculated egg success for 20 of the 23 successful nests in 1997 (Table 2).

Of 106 eggs laid, 21 (19.8%) did not hatch. Seven of 106 (6.6%) were infertile, and 3 (2.8%) were decomposed. Eleven (10.4%) contained developed embryos that had not pipped. Overall, 21 (19.8%) did not hatch, for an egg success rate of 80.2%. As in 1996, we examined all of the eggs in 1997 that did not hatch and found no evidence of physical deformities. One egg contained twins; they were normal, but several days behind their nestmates in development.

Fledging Success....In 1996, 57 eggs hatched, and approximately 14 goslings (25%) survived to fledging. In 1997, 83 eggs hatched from 20 nests; 43 goslings (52%) survived to fledging. (Three nests containing a total of 13 eggs were counted as "successful" for nesting success estimation, however, they were abandoned as pipping eggs or hatchlings due to trapping efforts, so can not be used in fledging success estimation. Another 3 goslings from successful nests died immediately after hatching due to trapping efforts; they were not included in the count of 83 hatched eggs.)

In 1997, 37 goslings hatched in platform nests; 18 (48.6%) fledged. Forty-six goslings hatched in ground nests; 25 (54.3%) fledged. Platform and ground nest fledging success was not significantly different .

Effect of Location....We examined number of gosling deaths per use day on all brood-rearing impoundments (Table 3). One location, 'Green Pond,' was 800 m north of Harrison impoundment, and outside the refuge, and filled by runoff water from Harrison. Some broods moved from one pool to another. We counted deaths occurring during an overland move of more than 200 m as deaths 'in transit'. Overland moves of <200 m were not considered 'in transit.' Some deaths occurred during an interval when a brood was not located; these were recorded as 'unknown' deaths. Ibis and South Gadwall were considered as one location because movement from one to the other entailed merely a trip over a dike, and South Gadwall was more similar in specific conductivity to Ibis than to North Gadwall.

We examined data from 17 broods. Seven of the broods had radio-collared females. In 5 of the 10 broods without radio-collared females either one or both parents were collared. In the other 5 broods, neither adult was collared. We identified these broods by age of goslings and location. The 17 broods hatched 75 goslings. We counted the day the goslings hatched as day 0. By the end of day 1, all broods had left the nest. By the end of the 15th day following hatching there were 42 goslings (56%) left. Thirty-three goslings (44%) had died. The average number of deaths per use day (DPUDs) during this period was 0.042-0.045. Four locations had below average DPUDs: Harrison, Ibis/S. Gadwall, Pintail, and Shoveler. The range for "Unknown," 0.032-0.058, spans the average. Two locations, Mallard and Green Pond, had DPUD numbers that ranged from 0 to above average. Four locations had above average DPUDs: Egret, Curlew, N. Gadwall, and 'in transit'.

DISCUSSION

Predation

Broods are especially vulnerable to predation the first few days following hatch. when they trek overland from nesting areas to brood-rearing areas. We suspect that predation was a major cause of mortality of goslings that disappeared while "in transit" at Fish Springs NWR. The timid behavior of nesting geese suggests that defense of goslings against predators is non-existent or ineffectual. Often, weaker or smaller goslings were not able to keep up with the rest of their brood during these long treks through saltgrass or upland desert. Our observations suggest that wary parents often abandoned slower young when disturbed or threatened while on land.

Egret impoundment had a very high number of DPUDs in 1997. In 1996, only one brood hatched or spent time there. The female was collared, and we watched as over the first 16 days her brood gradually decreased from 5 to 1. One week later the single-member brood left the Egret impoundment. We suspect predation in these mortalities. In both years, we often observed broods grazing to the east of Egret dike, outside the impoundment. When we approached slowly in the truck, often adults and young would run into the upland desert, away from the safety of the water. We examined the area and found coyote tracks interspersed with goose tracks, and a coyote path along a low (4 m high) ridge that paralleled the dike and the grazing area. Additionally, in 1997, water levels were low enough to allow easy access by mammals to the islands and peninsulas within the pool. In 1996, one of our technicians observed a juvenile coyote with a dead adult goose in its mouth on Pintail impoundment. We also saw coyotes stalking geese, and teaching pups to do this.

Predation pressures is not equally probable across the impoundments. Larger, more open pools appear to be preferred by geese. For example, predation by coyote on Pintail impoundment appeared to be low, possibly for the following three reasons. First, in both years several broods congregated on this pool, and several adults were always alert. Thus, it was more likely that potential predators would be seen. Second, the impoundment is large and open, and visibility is good. Third, if broods fed on the north or south dikes they went either north or south when startled to the adjacent impoundments. If broods fed on the eastern or western edges of the pool, they were unlikely to be startled by the approach of our truck because these areas are not next to the dikes. Broods feeding in these areas would often become alert at our approach, but could get to the water without crossing in front of our vehicle, or going up and over a dike. They did not run into the upland desert.

Human Disturbance

The 3 concurrent deaths on the North Gadwall impoundment (see Table 3) present an interesting problem. A quote from Sherwood may lend some insight:

> Family ties are fragile the first three to four weeks of the goslings' lives. and a brood unit could be broken at the slightest extraordinary event. Vehicles on the dikes that caught broods unaware and separated them from the pool frequently wrought havoc. The brood panicked and dispersed in all directions with the parents usually heading for the pool and some goslings getting lost in dense vegetation. Parent geese rarely stopped to count "noses" and swam off with whatever portion of the brood they had left. Occasionally,

> the gander would hold back to wait for a straggler if he heard it calling. Consequently, driving the refuge dikes was held to a minimum.[3]

Most likely this is what happened on N. Gadwall, with a radio-collared female and her brood. On 11 May, day 1 after hatching, we saw the brood with 5 goslings. On 12 May, day 2 after hatching, as we drove along the N. Gadwall road the same sequence of events that Sherwood observed occurred. The next day, we sighted the brood with only 2 goslings. This observation is made even more interesting by the fact that similar events took place with 3 other broods.

W found more circumstantial evidence for the role human disturbance may play in gosling mortality at Fish Springs NWR in archived letters and reports. In a letter dated 15 September 1967, then refuge manager Robert G. Yoder remarked: "Mortality seemed less than usual this year as very few goslings (up to two weeks old) found dead on the dikes or roads. Last year I can recall picking up 4 or 5 dead goslings at this age." That goslings were found dead in plain view suggests that predators were not responsible for the mortalities, nor were predators or scavengers present in great numbers or the bodies would not have been found. Additionally, we found historical references to "control of predators which may constitute a menace to the captive birds...". Because broods often feed along the dikes, unsuspecting refuge personnel may have inadvertently and unknowingly startled them, causing the parents to flee and abandon the slowest goslings.

In 1990, J. Engler lamented that neither he nor any other refuge employee was able to do any observations in late April and May due to lack of personnel. The majority of the broods hatched in late April and early May, and the critical first 15-day period was over by the time Engler was able to do brood observations. The highest

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[3] Sherwood, G. A. 1966. Canada geese of the Seney National Wildlife Refuge. PhD. Dissertation. Utah State University, Logan. 319 pp.

fledging success from 1989 to 1993 was reported in 1990. This may merely be coincidence, but it suggests that the lack of human disturbance may be causally related to higher fledging success.

CONCLUSIONS

Gosling production at Fish Springs NWR in 1996 and 1997 was limited due to 3 factors: low number of breeding pairs, low nest success for ground nests, and low fledging success. Gosling survival to fledging was independent of salinity of gosling location during the first 15 days following hatching. Predation and human disturbance appear to be important causes of gosling mortality.

MANAGEMENT RECOMMENDATIONS

If increased gosling production is desired, we recommend the following 3 actions:

1. Monitor specific conductivity of brooding impoundments on a weekly basis. Take steps to decrease salinity if levels rise above 12 μS/cm during the early part of the brood rearing season.
2. Encourage geese to rear their broods on "successful" impoundments (*viz.*, Harrison and Pintail) by installing more platforms within them.
3. Minimize human disturbance of broods by closing the northern half of the refuge to vehicular and other traffic from 15 April (when the first broods hatch) to 15 July (when most goslings are fledged or close to fledging) every year.

When the refuge was established in 1959, the emphasis of the U.S. Fish and Wildlife Service (USFWS) was on producing surplus waterfowl, particularly ducks and geese, for harvest by hunters. In recent years, the mission of the USFWS has been modified to include management of a more diverse fauna, with increasing attention given to non-game species. Fish Springs NWR supports breeding populations of such sensitive species as the white-faced ibis (*Plegadis chihi*), snowy plover (*Charadrius alexandrinus*), and sandhill crane (*Grus canadensis*). It has several large rookeries of ibis, snowy egret (*Egretta thula*), great blue heron (*Ardea herodias*), and black-crowned night-heron (*Nycticorax nycticorax*), and provides habitat for migrating songbirds. Since the western Canada goose has healthy breeding populations in many other wetlands in Utah, and other parts of its range, Fish Springs NWR may wish to concentrate its efforts on other avian species.

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DSS & JAB

Table 1. Comparison of mortality from day 2 to day 15 of Canada goose goslings at high (≥ 8.2 µS/cm) and low (< 8.2 µS/cm) conductivity locations at Fish Springs NWR, Juab County, Utah, 1997, using a chi square test of independence[a].

	Number dead[b]		Number alive	
	Observed	Expected	Observed	Expected
Low conductivity	20(74)	14(52)	13(36)	19(53)
High conductivity	7(26)	13(48)	23(64)	17(47)
TOTALS	27(100)	27(100)	36(100)	36(100)

[a] $\chi^2 = 9.35$; $P = 0.0093$
[b] Percentages of column totals in parenthesis

Table 2. Egg success for eggs from successful nests of Canada geese at Fish Springs NWR, Juab County, Utah, 1996 and 1997.

Year	No. nests	Total no. eggs	Average clutch size	Number infertile eggs	Number rotten eggs	Number normal[a] eggs	Total hatched (egg success)[b]	Average hatch per nest
1996	14	75	5.4	2 (2.7%)	1 (1.3%)	2 (2.7%)	70 (93.3%)	5.0
1997	20	106	5.3	7 (6.6%)[c]	3 (2.8%)	11 (10.4%)[d]	85 (80.2%)	4.25

[a] We use "normal" to designate unhatched eggs with normal embryos that did not begin pipping.
[b] Pipping eggs from nests that were abandoned due to trapping efforts and subsequently did not hatch are counted as hatched for this calculation.
[c] Five of the infertile eggs were from one nest that also contained 5 fertile eggs.
[d] Our activities at the nest may have caused broods to leave earlier than they would have normally, abandoning unhatched eggs; as many as 7 eggs may have been affected by this.

Table 3. Number of Canada goose gosling deaths per use day from day 1 through day 15 after hatching at various locations at Fish Springs NWR, Juab County, Utah, 1997.

Location	No. of use days[a]	No. of deaths[b]	Deaths per use day
Ibis/S. Gadwall	143-144	2	0.014
Harrison	184-187	2-3	0.011-0.016
Pintail	162-163	3	0.018
Shoveler	43	1	0.023
Unknown	69-95	3-4	0.032-0.058
Green Pond	10-12	0-1	0-0.100
Egret	75-104	10-12	0.096-0.160
Curlew	6	1	0.167
N. Gadwall	12	3	0.250
In Transit	17-19	1-8	0.053-0.471
Mallard	6	0-3	0-0.500
TOTALS	**727-791**	**33[c]**	**n.a.**
AVERAGE	**n.a.**	**n.a.**	**0.042-0.045**

[a] Ranges in number of use days resulted from days when we located a brood but were unable to make an exact count of goslings.
[b] Ranges in number of deaths at a specific location resulted from us pinpointing mortality to one of 2 locations, rather than to the exact location.
[c] Exact number of mortalities.

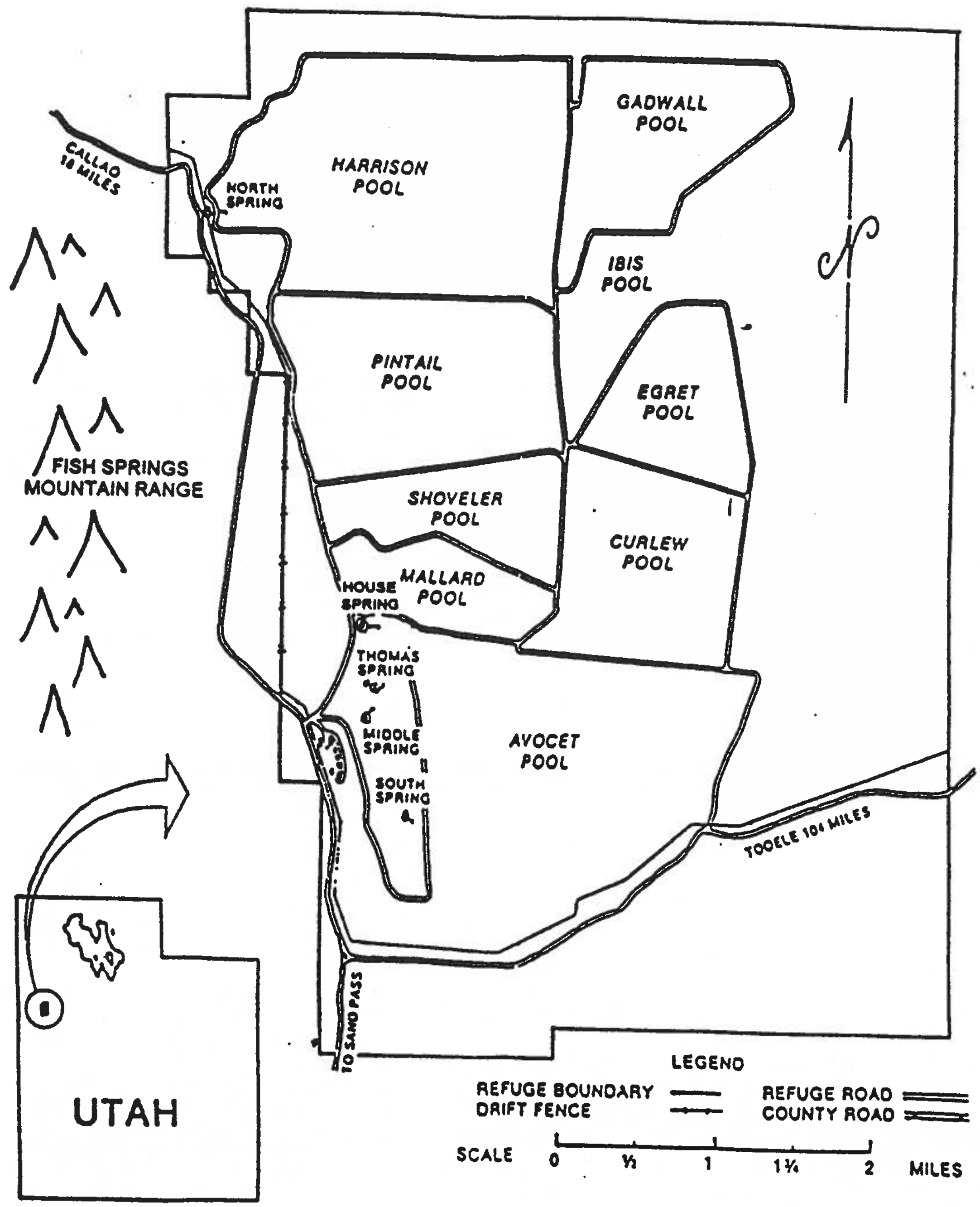

Figure 1. Fish Springs National Wildlife Refuge, Juab County, Utah.

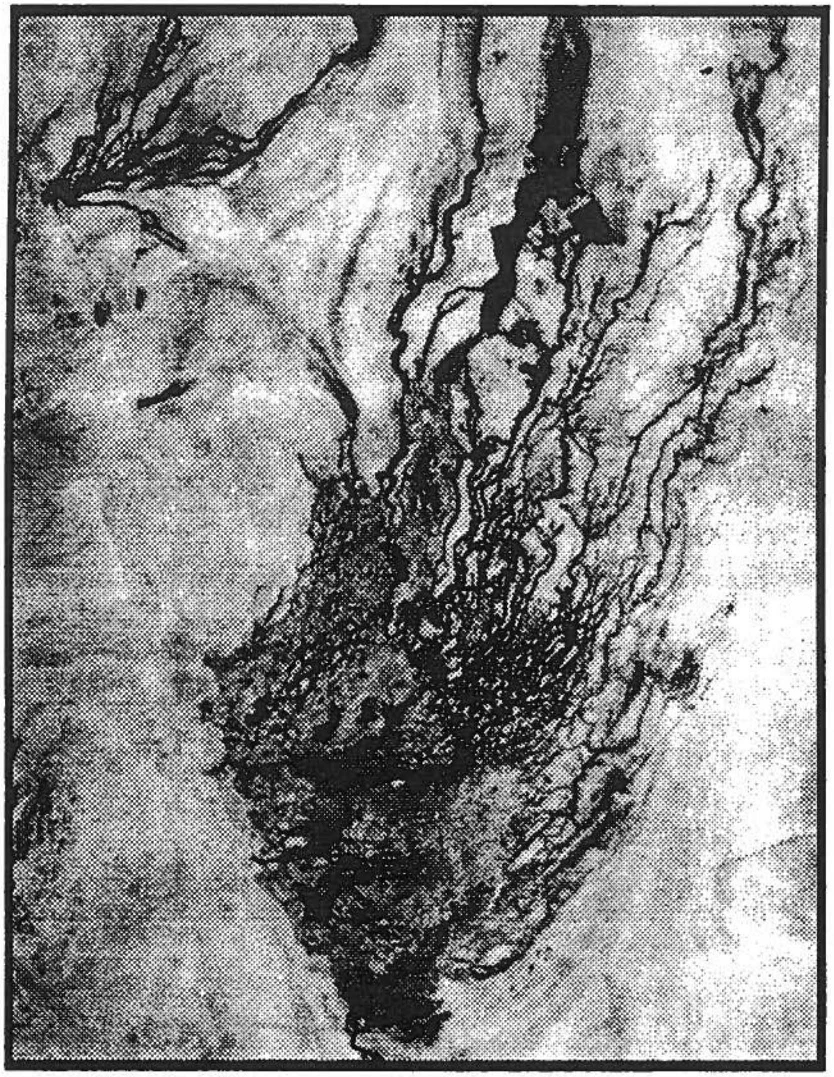

Figure 2. The sloughs and marsh at Fish Springs before modification of the wetlands (*circa* 1960), Juab County, Utah.